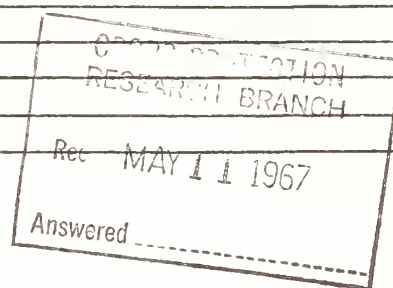




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Costs of Transporting Bulk and Packaged **MILK** by Truck



MARKETING RESEARCH REPORT NO. 791

ECONOMIC RESEARCH SERVICE • U.S. DEPARTMENT OF AGRICULTURE

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SUMMARY

Costs for long distance transportation of bulk milk were developed for the Eastern, Midwest, and Western Regions of the United States, and combined for a three-region average. Synthetic cost analysis was used to derive annual fixed costs and variable costs per unit of milk for each region.

Fixed costs were converted to an hourly basis and applied to total truck utilization time per round trip for varying distances. The resulting fixed cost per trip, plus the total variable cost per trip, plus the milk transfer cost, yielded the total cost per trip.

Total trip costs were analyzed further on the basis of (1) hundredweight, (2) mileage, and (3) hundredweight per mile. Total transportation cost functions were developed from the data.

Results indicated that for distances up to 29-39 miles one way, depending on the region, one-driver trucks with 30,000-pound payloads would be used to haul bulk milk directly to plants. For distances greater than 29-39 miles and up to 200 miles one way, one-driver trucks with 49,000-pound payloads would yield the lowest cost per unit of milk; for distances greater than 200 miles one way, two drivers per truck would be the least-cost operation.

Costs per hundredweight of milk for various distances were computed. For 100 miles one way, the cost per hundredweight per mile would be .2123 cent in the East, .2121 cent in the Midwest, and .2235 in the West. As distance increased, the unit cost would decrease. For example, for 1,000 miles one way the cost per hundredweight per mile was .1226, .1241, and .1246 cent for the East, Midwest, and West, respectively. These conclusions assume no return load.

There was an indication that hauling charges for less than 150 miles were low compared with costs. On the other hand, for distances greater than 150 miles, hauling charges tended to be higher than hauling costs.

In addition to bulk milk transportation costs, costs for transporting packaged milk were developed. This was done by adjusting the basic cost data for bulk milk to conform with the types of equipment and techniques used for packaged milk transportation.

The cost per hundredweight per mile for hauling packaged milk averaged .2173 cent for 100 miles one way and .1643 cent for 1,600 miles.

COSTS OF TRANSPORTING BULK AND PACKAGED MILK BY TRUCK

by Orval Kerchner 1/

INTRODUCTION

Modern highways and truck equipment have facilitated movement of milk over long distances. The consumer in any part of the country can obtain milk which has been produced on a farm 1,000 or more miles away. Transporting milk over such distances requires equipment of functional design and efficient operation. This study deals with costs of transporting bulk milk over long distances and with costs of transporting packaged milk from plant to distribution centers.

COSTS OF BULK MILK TRANSPORTATION

The synthetic or building-block method of analysis was used to develop transportation costs for hauling bulk milk. These costs, with appropriate adjustments, were used to derive packaged milk transportation costs. All costs were developed from specific input-output data. Some of the assumptions were based on information obtained from a trucking firm, several milk haulers, and equipment dealers throughout the United States.

The two sizes of trucks included in this analysis were a tractor-trailer unit with a payload capacity of 3,500 gallons (30,000 pounds), and a unit with a payload of 5,700 gallons (49,000 pounds). The larger unit was assumed to have a diesel-powered tractor equipped with a tandem-drive axle and a sleeper cab. The trailer, also equipped with tandem axel, carried a stainless steel tank meeting sanitary and construction requirements for hauling bulk milk. The smaller unit was assumed to be similar to the larger one in all respects except that it carried a smaller payload, and used a smaller tractor without a sleeper cab.

As considered here, bulk milk hauling includes milk loaded on trucks to be shipped to a plant. The smaller unit was used to pick up milk from farms and haul it to a plant, while the larger one was used for shipping milk from plant to plant. This study excludes the actual operation of picking milk up from farms, but not the use of trucks with 30,000-pound payloads to haul milk to plants. The point where a small truck was loaded with milk was considered as the zero-mile location in the analysis of transportation costs.

In the analysis, yearly fixed costs were converted to an hourly basis. It was assumed that a truck could be available for duty 8,760 hours per year (365 days x 24 hours). In other words, truck costs would be incurred each hour of the year whether the truck was hauling milk, being repaired, or standing idle.

Because of seasonality of milk production and plant receipts, however, milk would not be available to fill a complete hauling schedule of 8,760 hours per year. Therefore, the total hours per year were adjusted on the basis of a conversion factor developed from data presented by Butz (2, table 3, p. 9). 2/ The adjustment

1/ Dr. Kerchner, formerly agricultural economist with the Marketing Economics Division, Economic Research Service, is currently with the Department's Planning Evaluation and Programming Staff.

2/ Underscored numbers in parentheses refer to items in the Bibliography, p. 21 .

thus reflected increased costs associated with fewer hauls, or, in terms of time, fewer hours of total truck time required to haul the available milk. The yearly average volume of milk shipments for fluid use divided into the high-month volume yielded a conversion factor of 1.48. Application of this factor to the 8,760 total hours per year resulted in 5,919 hours per year. The 5,919 figure, assumed to be the maximum number of hours the truck could be used during one year, was used later to determine hourly fixed costs. If another assumption concerning seasonality were used, a different number of hours per year of total truck time would be applicable.

Truck utilization was determined on an hourly basis for various lengths of trips. It was assumed that one truck would be used for various trips. (See Appendix, Truck Usage, for further explanation.) A number of constant and variable times were involved in each trip (table 1). Certain functions required a fixed number of hours per trip, while others varied depending on the length of the trip. Checkout, loading, and unloading required a fixed amount of time, while the hours needed for driving, maintenance, and layover varied with distances.

It was assumed that 1 hour was required before each trip to check out the equipment and prepare it for use.

Loading and unloading times generally depend on the type of equipment at the plants. The larger unit required 2 hours and 1.5 hours for loading and unloading, respectively. No loading time was designated for the smaller unit as it would have completed its load and been ready for the trip to the plant or transfer point. One hour was needed for unloading, assuming the pump on the small truck had a capacity of 70 gallons per minute.

Repairs, lubrication, and other maintenance were prorated according to mileage per trip. Driving time was based on a truck speed of 40 m.p.h.

Layover time for a one-driver operation was based on the Interstate Commerce Commission (ICC) regulation that a driver must rest for an 8-hour period after 10 hours of duty time. Therefore, based on a speed of 40 m.p.h. for each 400-mile trip, this 8-hour period was added to truck time. If two drivers were used, layover time was not added. The ICC regulations permit continuous operation of the truck, provided drivers relieve each other at the wheel and a sleeping compartment is available for the off-duty driver.

Another factor in truck utilization--idle time--was based on the time involved in waiting to pick up or deliver a load of milk at a plant. It was assumed that the larger unit picked up or delivered a load of milk between 5 a.m. and 1 p.m. Maximum idle time for all trips was assumed to be 16 hours (table 1). The smaller unit was assumed to be available for only one load of milk per day. Thus, idle time was a residual factor in that part of the analysis and was assumed to be sufficient to pick up farm milk. This assumption was based on a recent Missouri study showing that total pickup time per load did not exceed 12 hours for a 30,000-pound load (17, table 10, p. 44).

Derivation of Costs

Fixed and variable costs were developed for the East, Midwest, and West. These regions identify the general area of the country in which the costs were most applicable. A weighted average for the three regions was derived from the regional cost data.

Table 1.--Hours required per trip to perform various functions, by size unit and round-trip mileage, bulk milk transport unit, 1966

Round-trip mileage and size unit	Function							Total truck time	
	Check- out 1/	Loading 2/	Unloading 3/	Mainte- nance	Driving time 4/	Driver: layover: 1 man 5/	Idle time 6/	1 driver	2 drivers
-----Hours-----									
<u>30,000-pound payload</u>									
Number of miles:									
10.....	1	---	1	0.10	0.25	0	21.65	24.00	---
20.....	1	---	1	.10	.50	0	21.40	24.00	---
40.....	1	---	1	.12	1.00	0	20.88	24.00	---
50.....	1	---	1	.15	1.25	0	20.60	24.00	---
70.....	1	---	1	.18	1.75	0	20.07	24.00	---
80.....	1	---	1	.20	2.00	0	19.80	24.00	---
100.....	1	---	1	.25	2.50	0	19.25	24.00	---
150.....	1	---	1	.38	3.67	0	17.95	24.00	---
200.....	1	---	1	.50	5.00	0	16.50	24.00	---
<u>49,000-pound payload</u>									
Number of miles:									
100.....	1	2	1.5	.25	2.50	0	16.00	23.25	23.25
200.....	1	2	1.5	.50	5.00	0	16.00	26.00	26.00
300.....	1	2	1.5	.75	7.50	0	16.00	28.75	28.75
400.....	1	2	1.5	1.00	10.00	0	16.00	31.50	31.50
410.....	1	2	1.5	1.00	10.25	8	16.00	39.75	31.75
800.....	1	2	1.5	1.50	20.00	8	16.00	50.00	42.00
810.....	1	2	1.5	1.50	20.25	16	16.00	58.25	42.25
1,200.....	1	2	1.5	2.50	30.00	16	16.00	69.00	53.00
1,210.....	1	2	1.5	2.50	30.25	24	16.00	77.25	53.25
1,600.....	1	2	1.5	3.00	40.00	24	16.00	87.50	63.50
1,610.....	1	2	1.5	3.00	40.25	32	16.00	95.75	63.75
2,000.....	1	2	1.5	4.00	50.00	32	16.00	106.50	74.50
2,010.....	1	2	1.5	4.00	50.25	40	16.00	114.75	74.75
2,400.....	1	2	1.5	4.50	60.00	40	16.00	125.00	85.00
2,410.....	1	2	1.5	4.50	60.25	48	16.00	133.25	85.25
2,800.....	1	2	1.5	5.00	70.00	48	16.00	143.50	95.50
2,810.....	1	2	1.5	5.00	70.25	56	16.00	151.50	97.75
3,200.....	1	2	1.5	5.50	80.00	56	16.00	162.00	106.00
3,210.....	1	2	1.5	5.50	80.25	64	16.00	170.25	106.25

1/ Time needed to inspect truck prior to loading and travel.

2/ Unit with 30,000-pound payload assumed to be loaded.

3/ Pump on small truck assumed to have capacity of 70 gallons per minute. Large truck unloaded by larger pumps in dairy plant.

4/ Based on average speed of 40 m.p.h.

5/ Interstate Commerce Commission regulations specify driving time not to exceed 10 hours without 8 consecutive off-duty hours.

6/ Maximum time which might be incurred due to scheduling truck to meet pickup and delivery time specified by plants. It was assumed truck with 30,000-pound payload would have only 1 load per day.

7/ Use of a second driver permits driver exchange without layover time, provided a sleeper cab is available.

Fixed Costs

The fixed costs synthesized for each of the regions consisted of depreciation, insurance, interest, Federal highway-use tax, license and miscellaneous tax, management and office salaries, and administrative costs (table 2).

Table 2.--Annual fixed costs per truck, by region and size of truck, bulk milk transport unit, 1966

Cost item	49,000-pound payload 1/				30,000-pound payload			
	East	Midwest	West	Average	East	Midwest	West	Average
-----Dollars-----								
Depreciation:								
Equipment 2/.....	3,829	3,586	4,343	4,919	2,899	2,646	3,397	2,980
Building and tools 3/.....	220	250	225	232	220	250	225	232
Insurance.....	1,025	1,000	1,581	1,202	1,000	975	1,556	1,177
Interest 4/.....	990	930	1,080	1,000	735	672	828	744
Federal highway-use tax.....	180	180	180	180	180	180	180	180
License and miscellaneous tax:	525	800	643	656	470	758	601	609
Management and office salaries 5/.....	973	973	973	973	973	973	973	973
Administrative costs 6/.....	649	649	649	649	649	649	649	649
Total.....	8,391	8,368	9,674	8,811	7,126	7,103	8,409	7,544
Per hour (adjusted) 7/.....	1.4177	1.4138	1.6344	1.4886	1.2039	1.2000	1.4207	1.2745
Per hour (unadjusted 8/....	.9579	.9553	1.1043	1.0058	.8135	.8108	.9599	.8612

1/ Unit used primarily for intermarket shipments. 2/ Tandem tractor and tandem trailer.

3/ Maintenance shop and office space. 4/ Rate of 6 percent.

5/ Supervision and clerical personnel plus a return to management.

6/ Includes office supplies, utilities, legal fees, and miscellaneous office expenses.

7/ Based on 5,919 hours of operation per year. 8/ Based on 8,760 hours of operation per year.

Equipment depreciation was based on an estimated purchased price for tractor and trailer units in each region (table 3). Cost estimates for new equipment were based on information from haulers and equipment dealers. A salvage value of \$1,000 each was assumed for the tractor and trailer, with a life of 7 years for the tractor and 10 years for the trailer.

Building depreciation, estimated from building, office, and ship equipment costs as supplied by haulers, was assigned on a per truck basis (table 3). The building was assumed to have a life of 33 years.

Interest charges were based on an interest rate of 6 percent of the midlife value of the equipment.

Insurance, licensing, and taxes were synthesized from information obtained from haulers, State licensing and insurance regulations, and insurance companies.

Costs for management and office salaries and administration were developed from data obtained in a 1960 survey (8, table 4, p. 12). These costs were assumed

Table 3.--Equipment valuation and depreciation, by size unit
and region, bulk milk transport unit, 1966

Region and equipment	49,000-pound payload			30,000-pound payload		
	New cost	Salvage value	Yearly deprec- iation 1/	New cost	Salvage value	Yearly deprec- iation 1/
	:	:	:	:	:	:
	<u>Dollars</u>					
East:						
Tractor.....	18,000	1,000	2,429	13,800	1,000	1,829
Trailer.....	15,000	1,000	1,400	10,700	1,000	1,070
Total.....	33,000	---	3,829	24,500	---	2,899
Midwest:						
Tractor.....	17,000	1,000	2,286	12,800	1,000	1,686
Trailer.....	14,000	1,000	1,300	9,600	1,000	960
Total.....	31,000	---	3,586	22,400	---	2,646
West:						
Tractor.....	23,000	1,000	3,143	18,200	1,000	2,457
Trailer.....	13,000	1,000	1,200	9,400	1,000	940
Total.....	36,000	---	4,343	27,600	---	3,397
United States:						
Tractor.....	19,300	1,000	2,619	14,933	1,000	1,990
Trailer.....	14,000	1,000	1,300	9,900	1,000	990
Total.....	33,300	---	3,919	23,833	---	2,980

1/ Equipment depreciation was assumed to be 7 years for the tractor and 10 years for the trailer.

to be the same in all regions. The administrative costs included items such as supplies, legal fees, and utilities. A return to management was assumed to be included in the management and office salaries category.

Fixed costs per hour for each region were derived by applying yearly hours of operation to yearly fixed costs. The fixed costs per hour were then used to determine the fixed cost for various round trips. The fixed cost varied with the number of hours associated with various distances and other factors.

Variable Costs

Variable costs, developed on a mileage basis for trucks with 49,000-pound payloads, consisted of fuel, labor, tires, maintenance, and miscellaneous (table 4). These costs were assumed to be applicable to the smaller unit (30,000-pound payload) as well.

Fuel consumption expressed in miles per gallon of diesel fuel was 6.4, 5.5, and 5.9 in the East, Midwest, and West, respectively. Fuel costs for the three regions averaged about 4 cents per mile (table 4).

Labor costs included base wages, pension and welfare contributions, social security, unemployment compensation, and workmen's compensation (table 5). The base wages for one and two drivers per truck were obtained from labor con-

Table 4.--Variable costs per mile to operate bulk milk trucks,
by region, 1966

Cost item	East	Midwest	West	Average
	-----Dollars-----			
Fuel, diesel 1/.....	0.0341	0.0465	0.0400	0.0402
Labor, 1 driver 2/.....	.1203	.1187	.1188	.1193
Tires 3/0244	.0166	.0250	.0220
Maintenance: 4/.....				
Grease and oil.....	.0076	.0076	.0076	.0076
Repairs.....	.0151	.0151	.0151	.0151
Labor.....	.0092	.0092	.0092	.0092
Miscellaneous 5/.....	.0130	.0100	.0050	.0093
Total, 1 driver.....	.2237	.2237	.2207	.2227
Labor, add 2d driver 2/.....	.0141	.0178	.0138	.0152
Total, 2 drivers.....	.2378	.2415	.2345	.2379

1/ From milk hauler data.

2/ From table 5.

3/ Computed from data on tire cost, mileage, and recapping cost and mileage.

4/ Based on 6-months data for 75 tractors.

5/ Includes road tolls, weighing fees, and other transportation expenses.

Table 5.--Labor costs per mile for one and two drivers,
by region, bulk milk transport unit, 1966

Cost item	One driver			Two drivers		
	East	Midwest	West	East	Midwest	West
	-----Cents per mile-----					
Base wage 1/.....	10.375	10.250	10.250	11.785	12.035	11.625
Pension and welfare 2/.....	.800	.800	.800	.800	.800	.800
Social security 3/.....	.355	.355	.355	.355	.355	.355
Unemployment compensation 4/..	.138	.138	.138	.138	.138	.138
Workmen's compensation 5/.....	.362	.328	.338	.362	.328	.338
Gross wage.....	12.030	11.871	11.881	13.440	13.656	13.256

1/ Data obtained from BLS labor contract file for tank truck drivers.

2/ Based on \$12 per week and 1,500 miles per week.

3/ Rate of 4.2 percent on first \$6,600.

4/ Rate of 3.6 percent on first \$3,000.

5/ East: \$3.53 per \$100 payroll.

Midwest: \$3.20 per \$100 payroll.

West: \$3.30 per \$100 payroll.

tracts for tank truck drivers on file with the Bureau of Labor Statistics (BLS). The two-driver base wage was less than twice the one-driver wage because no layover time was involved. On long distances where a layover for one driver would be required, two drivers could travel the same number of miles in a shorter time; therefore, on a time basis, wages per driver would tend to be the same whether one or two drivers were employed. The labor benefits were computed on a mileage basis, assuming a driving distance of 1,500 miles per week. These benefits, added to the base wage, yielded the one- and two-driver gross wage for each region.

The basic data for deriving tire wear and cost were obtained from haulers and tire dealers (table 6). Variations in tire life among regions were apparently due to differences in road conditions affecting tire wear. Tire cost per mile was computed assuming a total of 18 tires and tubes per truck.

Data on maintenance were obtained from a regional trucking organization, which furnished maintenance records on 75 tractors for 6 months. These records were used to compute the cost of grease and oil, repairs, and maintenance labor per truck. The same maintenance costs per mile were used in all regions.

Miscellaneous variable costs included road tolls, weighing fees, and fines. These data were developed from 1965 accounting records of a hauler located in the East. Miscellaneous costs in each of the other regions were assumed to be lower because fewer toll roads were likely to be used.

Transfer Cost

In addition to fixed and variable cost factors, a transfer cost of 4 cents per hundredweight was assumed for milk hauled in bulk transport units. This amount covered the cost of transferring milk from a smaller truck directly to the larger truck at a reload station. Transfer costs would be different if milk were pumped through a holding tank at a plant site, but these costs were not analyzed in this study.

Table 6.--Tire cost and wear for a bulk milk transport unit, by region, 1966

Item	Units	East	Midwest	West	Average
Original tire cost.....	Dollars	120	115	120	118
Original tread wear.....	Miles	60,000	100,000	65,000	75,000
Recapping cost (2) 1/.....	Dollars	70	70	80	74
Recap tread wear (2) 2/...	Miles	80,000	100,000	80,000	85,000
Total cost.....	Dollars	190	185	200	192
Total miles.....	Miles	140,000	200,000	145,000	160,000
Cost per tire per mile...	Cents	.1357	.0925	.1379	.1200
Cost per truck per mile...	Cents	2.44	1.66	2.50	2.20

1/ Assumes 2 recappings per tire.

2/ Assuming 18 tires.

The sum of the fixed costs, variable costs, and transfer cost yielded a total cost figure, varying according to the length of round trip. Various lengths of round trips were used to derive the total transportation costs in each region and to develop cost functions related to mileage and a fixed volume of milk transported. ^{3/}

Results of Analysis

The total cost figures were used to compute various average costs for each region (table 7). The three average costs were in terms of (1) hundredweight, (2) mileage, and (3) hundredweight per mile, with each related to distances milk was hauled.

The hundredweight costs for various distances were used to develop a series of total cost functions for transporting milk. These functions relate hundredweight costs to one-way mileage and assume no back haul. The place where trucks with 30,000-pound payloads were completely loaded was designated as the origin.

The total cost functions for the three regions and their averages are listed in table 8 and the averages are illustrated in figure 1. There are six functions for each region, indicating the effects of the truck utilization times as related to mileage (table 1). The graph in figure 1 is segmented, with kinks at 36, 100, 400, and 800 miles and a discontinuity at 200 miles.

Beyond 200 miles, two drivers were required on the truck, increasing labor cost by the amount of the additional driver wage. The one-driver truck did not remain in operation past 200 miles because the layover period increased investment cost by an additional 8 hours of time. The additional cost associated with the one-driver truck was greater than that of the two-driver truck; therefore, the two-driver truck was the lowest cost unit beyond 200 miles.

The first of the six equations for each region represents the cost for trucks with 30,000-pound payloads. The second and third equations are for the one-driver units with 49,000 pounds of payload. Trucks with two drivers, represented by the remaining three equations in each region, are applicable to one-way mileages in excess of 200 miles (table 8).

The discontinuous function is again illustrated in figure 2, where the cost per hundredweight per mile is shown related to mileage. A round trip of more than 400 miles required the use of two drivers; the resulting increase in costs appears as a step function in the chart.

To illustrate this step function, consider table 7 and the column titled "Average: per hundredweight per mile." At 200 miles the cost was .1610 cent, but at 205 miles the cost was .1659 cent, an increase of .0049 cent. This represents the increased cost associated with the addition of the second driver beyond 200 one-way miles.

The average cost curve for each region descends sharply from the zero mile axis, is discontinuous at 200 miles, and tends to flatten out beyond 400 miles. The lowest average cost up to 200 miles one way occurs in the Midwest. Beyond this distance, the East has the lowest cost (fig. 2 and table 7).

^{3/} For a symbolic derivation of total cost per mile, see the appendix, p.22.

Table 7. -- Estimated cost of transporting bulk milk over various distances
based on 5,919 hours per year, by region, 1966 ^{1/}

One-way mileage ^{2/}	East			Midwest			West			Average		
	Per cwt.	Per mile	Per cwt. : per mile	Per cwt.	Per mile	Per cwt. : per mile	Per cwt.	Per mile	Per cwt. : per mile	Per cwt.	Per mile	Per cwt. : per mile
-----Cents-----												
5.....	10.433	1,013.530	2.0866	10.312	1,010.600	2.0624	12.063	1,182.181	2.4126	10.907	1,068.879	2.1814
10.....	11.083	543.067	1.1083	11.053	541.602	1.1053	12.794	626.904	1.2794	11.644	570.579	1.1644
20.....	12.571	307.999	.6286	12.542	307.266	.6271	14.262	349.429	.7131	13.126	321.592	.6563
25.....	13.312	260.920	.5325	13.282	260.334	.5313	14.997	293.934	.5999	13.867	271.794	.5547
35.....	14.800	207.208	.4229	14.771	206.790	.4220	16.168	226.343	.4619	15.345	214.836	.4384
40.....	15.492	189.777	.3873	15.473	189.344	.3868	17.195	210.639	.4299	15.867	194.371	.3967
50.....	16.449	161.200	.3290	16.429	161.000	.3286	17.594	172.420	.3519	16.822	164.860	.3364
100.....	21.233	104.040	.2123	21.210	103.930	.2121	22.347	109.500	.2235	21.596	105.820	.2160
150.....	26.520	86.630	.1768	26.496	86.550	.1766	27.686	90.440	.1846	26.900	87.873	.1793
200.....	31.808	77.930	.1590	31.784	77.870	.1589	33.024	80.910	.1651	32.204	78.900	.1610
205.....	33.518	80.110	.1635	33.802	80.795	.1649	34.710	82.966	.1693	34.008	81.288	.1659
400.....	54.975	67.345	.1374	55.547	68.045	.1388	56.294	68.960	.1407	55.600	68.110	.1390
405.....	55.535	67.190	.1371	56.112	67.889	.1385	56.855	68.788	.1404	56.161	67.948	.1387
600.....	77.571	63.350	.1292	78.435	64.055	.1307	79.106	64.603	.1318	78.363	63.997	.1306
605.....	78.128	63.278	.1291	79.000	63.983	.1306	79.667	64.524	.1317	78.924	63.922	.1305
800.....	99.922	61.202	.1249	101.180	61.972	.1265	101.751	62.322	.1272	100.973	61.846	.1262
805.....	100.481	61.163	.1248	101.745	61.932	.1264	102.312	62.277	.1271	101.535	61.804	.1261
1000.....	122.616	60.082	.1226	124.067	60.793	.1241	124.563	61.036	.1246	123.735	60.630	.1237
1200.....	145.065	58.485	.1209	146.810	59.948	.1223	147.208	60.110	.1227	146.345	59.758	.1220
1400.....	167.516	58.631	.1197	169.555	59.344	.1211	169.855	59.449	.1213	168.955	59.134	.1207
1600.....	189.967	58.178	.1187	192.298	58.891	.1202	192.500	58.953	.1203	191.565	58.667	.1197

^{1/} Assuming 49,000 pounds of milk.

^{2/} Doubling each mileage equals the round-trip mileage used in table 1. One-way mileage is used because rates quoted by the trade are expressed in terms of a one-way haul.

Table 8.--Bulk milk transportation cost functions, one-way mileages,
based on 5,919 hours per year, by region, 1966

One-way : mileage : interval :	Applicable equations 1/			
	East	Midwest	West	Average 2/
0 - 29.....:	NA	NA	$Y = 11.330 + .14663 X$	NA
0 - 36.....:	NA	NA	NA	$Y = 10.167 + .14795 X$
0 - 38.....:	$Y = 9.695 + .14767 X$	NA	NA	NA
0 - 39.....:	NA	$Y = 9.569 + .14862 X$	NA	NA
30 - 100.....:	NA	NA	$Y = 12.841 + .09506 X$	NA
37 - 100.....:	NA	NA	NA	$Y = 12.048 + .09548 X$
39 - 100.....:	$Y = 11.665 + .09568 X$	NA	NA	NA
40 - 100.....:	NA	$Y = 11.648 + .09562 X$	NA	NA
101 - 200.....:	$Y = 10.658 + .10575 X$	$Y = 10.636 + .10574 X$	$Y = 11.670 + .10677 X$	$Y = 10.988 + .10608 X$
201 - 400.....:	$Y = 10.963 + .11003 X$	$Y = 10.942 + .11151 X$	$Y = 12.019 + .11069 X$	$Y = 11.308 + .11073 X$
401 - 800.....:	$Y = 10.026 + .11237 X$	$Y = 9.902 + .11410 X$	$Y = 10.823 + .11366 X$	$Y = 10.214 + .11345 X$
801 plus.....:	$Y = 9.871 + .11256 X$	$Y = 10.056 + .11390 X$	$Y = 10.993 + .11344 X$	$Y = 10.369 + .11325 X$

1/ Y = cents per cwt. X = one-way mileage. NA = not applicable for given mileage interval. First equation in each region is for the smaller truck.

2/ The aggregate function (disregarding the 1- and 2-driver operations) for the larger unit traveling distances from 35 to 1,600 miles one way is $Y = 11.405 + .11260 X$.

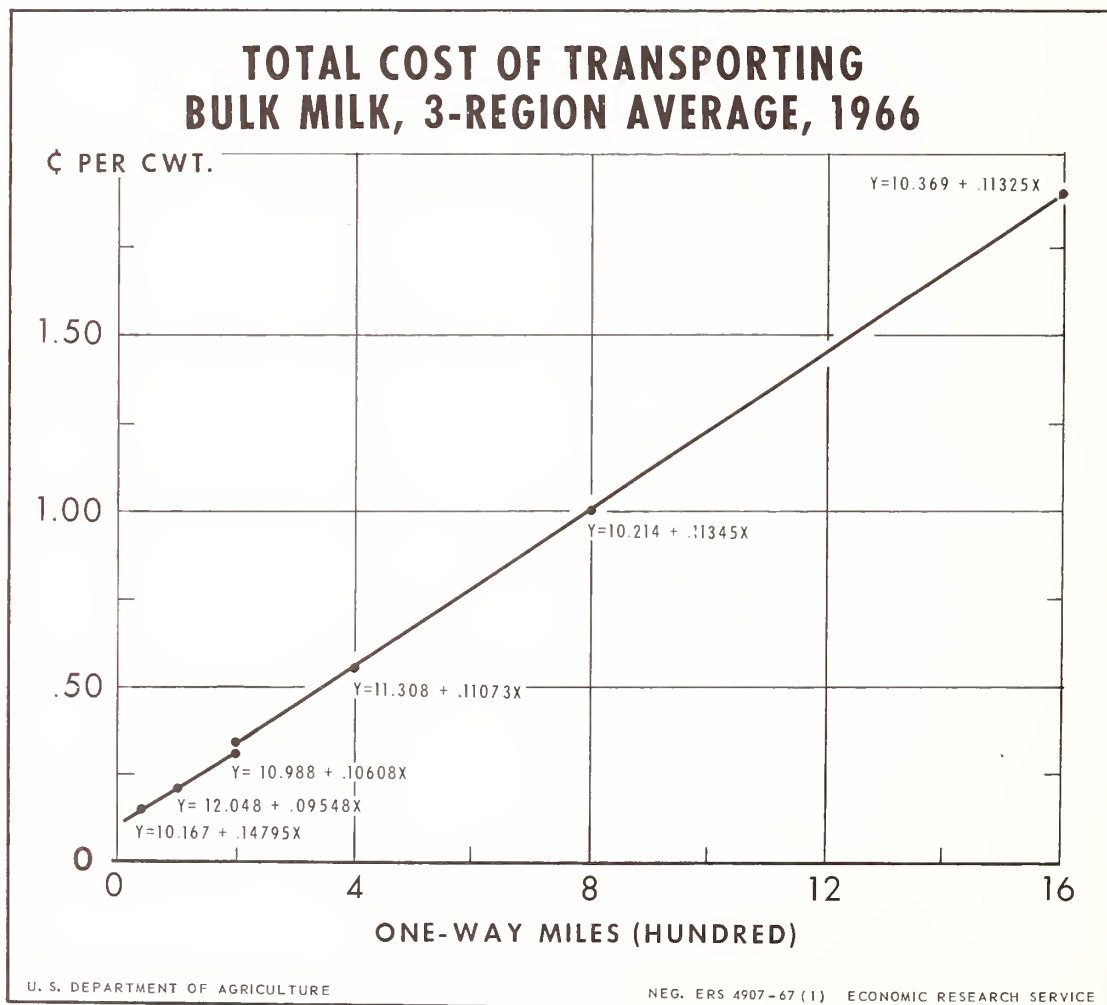


Figure 1

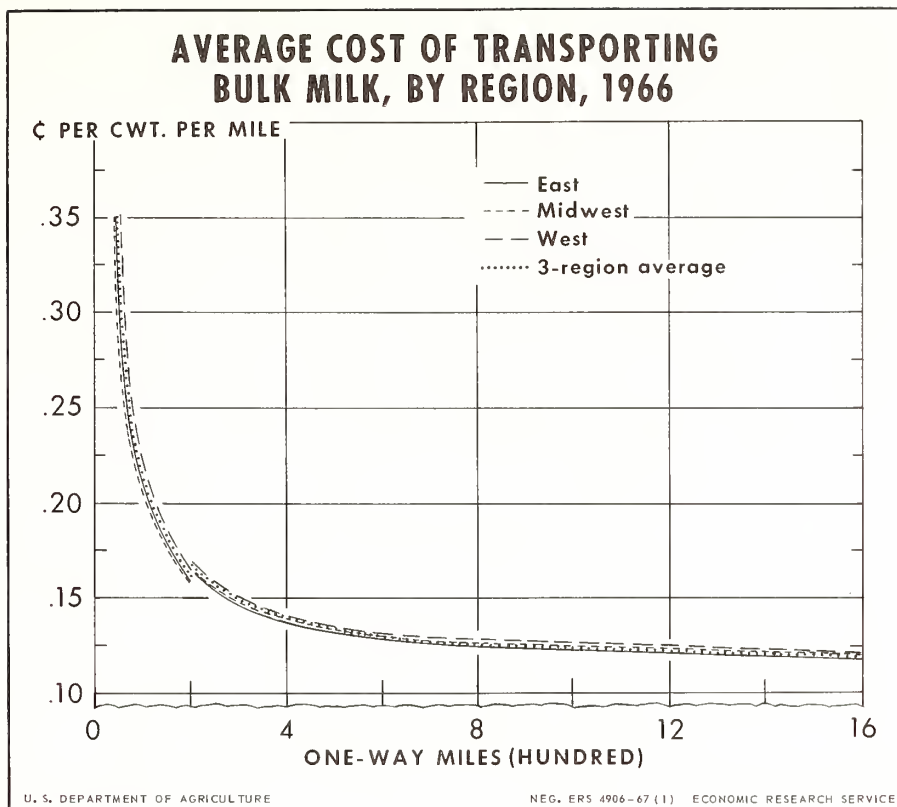


Figure 2

Seasonality Assumption Changed

In the foregoing analysis, the seasonality assumed in long-distance bulk milk shipments was accounted for in the total hours per year during which a truck would be used. For comparative purposes, another analysis of costs was made assuming no seasonality in milk shipments. This meant that milk would be available for shipment in approximately equal amounts throughout the year.

The fixed costs were adjusted in accordance with the assumption of regular shipments year-round. Therefore, the hourly fixed costs were based on 8,760 hours of total truck utilization available each year (table 2).

The effects of assuming regular shipments appear in the cost averages (table 9) and in the cost functions (table 10) for each region.

This analysis showed that smaller trucks could haul milk a few miles farther when seasonality of shipments was not taken into account. For example, when seasonality was considered, a unit with a 30,000-pound payload traveled 36 miles (table 8), but when seasonality was not considered, it traveled 48 miles (table 10) before the larger tractor-trailer unit was applicable.

The cost per hundredweight per mile was found to be less for any given distance when regular shipments were assumed than when seasonality of shipment was considered. At 800 miles, for example, the cost per hundredweight per mile for all regions averaged .1184 cent for regular shipments (table 9) and .1262 for seasonal shipments (table 7).

Table 10.--Bulk milk transportation cost functions, based on 8,760 hours per year, 1966 1/

One-way mileage interval :	Applicable equations <u>1/</u>			
	East	Midwest	West	Average <u>2/</u>
0 - 41.....:	NA	$Y = 6.396 + .16251 X$	NA	NA
0 - 44.....:	NA	NA	$Y = 7.655 + .14665 X$	NA
0 - 48.....:	NA	NA	NA	$Y = 6.868 + .14797$
0 - 50.....:	$Y = 6.486 + .14865$	NA	NA	NA
42 - 100...:	NA	$Y = 9.167 + .09422 X$	NA	NA
45 - 100...:	NA	NA	$Y = 9.972 + .09460 X$	NA
49 - 100...:	NA	NA	NA	$Y = 9.439 + .09398 X$
51 - 100...:	$Y = 9.180 + .09424 X$	NA	NA	NA
101 - 200...:	$Y = 8.496 + .10108 X$	$Y = 8.483 + .10106 X$	$Y = 9.183 + .10135 X$	$Y = 8.721 + .10116 X$
201 - 400...:	$Y = 8.703 + .10583 X$	$Y = 8.692 + .10731 X$	$Y = 9.419 + .10583 X$	$Y = 8.937 + .10631 X$
401 - 800...:	$Y = 8.101 + .10733 X$	$Y = 7.990 + .10906 X$	$Y = 8.610 + .10784 X$	$Y = 8.201 + .10814 X$
801 plus...:	$Y = 8.305 + .10732 X$	$Y = 8.091 + .10893 X$	$Y = 8.723 + .10769 X$	$Y = 8.306 + .10801 X$

1/ Y = cents per cwt. X = one-way mileage. NA = not applicable for given mileage interval. First equation in each region is for the smaller truck.

2/ The aggregate function (disregarding 1- and 2-driver operations) for the larger truck traveling distances from 50 to 1,600 miles is $Y = 8.752 + .10773 X$.

Bulk Hauling Costs Versus Bulk Hauling Charges

In his 1964 study, Butz reported that bulk milk hauling charges ranged from 16.7 cents to 17.2 cents per hundredweight per 100 miles (2, p. 12). He also noted that during 1958, milk from Wisconsin was hauled 600 or more miles at an average rate of 17.6 cents per hundredweight per 100 miles. Presumably, these rates were aggregates for all sizes of payload and represented charges assuming no, or very little, backhaul.

The hauling costs derived here and recorded in table 7 may be compared with the hauling charges discussed in the above paragraph. The U.S. hauling costs per hundredweight per mile ranged from .1793 cent at 150 miles to .1237 cent at 1,000 miles. At 800 miles, the average one-way distance in the Butz study, the cost was .1262 cent per hundredweight per mile.

The 1964 hauling study graphically related the charges per hundredweight and the distance hauled. A sample of 40 loads was used as the basis for comparison. Loads of 4,000 gallons or less, loads with more than 4,000 gallons, and loads with backhaul were included. The line of average relationships was $Y = 3.4 + .1597 X$, where Y equaled cents per hundredweight and X equaled one-way mileage. This indicated that hauling charges per hundredweight increased about .16 cent per additional one-way mile. Using this formula, it was found that at 800 miles the charge was .1640 cent per hundredweight per mile.

Comparison of the bulk hauling costs in this report with the 1964 hauling charge function indicates that the fixed costs are greater than those in the 1964 charge function. On the other hand, the cost per additional mile is less in the cost function than in the charge function.

Comparison of the average cost function for 401-800 one-way miles with the charge function shows that the two functions intersect at 147 miles. Considering an aggregate cost function, that is, excluding mileage interval differences, the cost function would intersect the charge function at 149 miles. (For cost per hundredweight per 100 miles, based on charges per loaded mile and volume of milk hauled, see table 11.)

This study suggests that bulk milk hauling charges tend to be below costs for distances under 150 miles and above costs for distances greater than 150 miles.

Some of the differences noted between the costs and charges can be explained. The costs were based on a larger payload than that considered in the charge data. In the Butz study, the largest tanker held approximately 44,000 pounds of milk compared with 49,000 pounds in the cost study. Thus, at greater distances the costs per hundredweight for the 49,000-pound payload unit would be expected to be lower than for a smaller truck. This assumes there are economies of scale in milk hauling. The study did not present sufficient data to verify the existence of economies of scale.

TRANSPORTATION COSTS FOR PACKAGED MILK

Transportation costs for packaged milk were derived by making minor adjustments in the cost data for bulk milk. The changes made and the results of the analysis are presented in this section.

The bulk tank semitrailer was replaced with a 40-foot refrigerated trailer with tandem axle. Trailer capacity was 35,000 pounds of milk, based on 9 half-gallon paper cartons in each of 900 wire cases. It was assumed that the primary use of a large refrigerated semitrailer for hauling packaged milk was to haul milk from a dairy plant to a distribution center. The truck was assumed to be empty on the return trip to the plant.

The trailer and refrigeration unit used for packaged milk had higher costs than the bulk equipment (table 12). Yearly fixed operating costs per truck are shown in table 13.

The refrigeration unit was equipped with diesel power and cost 52 cents per running hour to operate. ^{4/} Total refrigeration operating time and cost for various mileages are indicated in table 14.

Time requirements to operate the packaged milk tractor and trailer unit varied from those for the bulk equipment (table 14). The most significant change occurred in loading time. With forklift trucks and palletized cases, the packaged milk could be loaded from the dairy plant in 1 hour. Since facilities at distribution centers were not always available for palletized merchandise, unloading time was assumed to be 1.5 hours. (Table 1 shows that the bulk milk hauling operation required 2 hours for loading and 1.5 hours for unloading.)

A fixed idle time of 16 hours per trip was assumed for all round-trip distances, the same as that used in the bulk milk operation. The fixed idle time takes into account specified pickup and delivery hours.

^{4/} The hourly operating cost for the refrigeration unit was based on information obtained from packaged milk haulers and cost estimates supplied by a refrigerated trailer dealer.

Table 11.--Cost to ship 100 pounds of milk 100 miles, based on volume of milk hauled and charge per loaded mile

Cents per loaded mile	Cents									
	17,200 lbs., 2,000 gals.	30,100 lbs., 3,500 gals.	34,400 lbs., 4,000 gals.	38,700 lbs., 4,500 gals.	43,000 lbs., 5,000 gals.	44,700 lbs., 5,200 gals.	47,300 lbs., 5,500 gals.	49,000 lbs., 5,700 gals.	51,700 lbs., 5,900 gals.	
45.....	26.16	14.95	13.08	11.63	10.47	10.07	9.51	9.18	8.70	
46.....	26.74	15.28	13.27	11.89	10.70	10.29	9.73	9.39	8.90	
47.....	27.33	15.61	13.66	12.14	10.93	10.51	9.94	9.59	9.09	
48.....	27.91	15.95	13.95	12.40	11.16	10.74	10.15	9.80	9.28	
49.....	28.49	16.28	14.24	12.66	11.40	10.96	10.36	10.00	9.48	
50.....	29.07	16.61	14.53	12.92	11.63	11.19	10.57	10.20	9.67	
51.....	29.65	16.94	14.83	13.18	11.86	11.41	10.78	10.41	9.86	
52.....	30.23	17.28	15.12	13.44	12.09	11.63	10.99	10.61	10.06	
53.....	30.81	17.61	15.41	13.70	12.33	11.86	11.21	10.82	10.25	
54.....	31.40	17.94	15.70	13.95	12.56	12.08	11.42	11.02	10.44	
55.....	31.98	18.27	15.99	14.21	12.79	12.30	11.63	11.22	10.64	
56.....	32.56	18.60	16.28	14.47	13.02	12.53	11.84	11.43	10.83	
57.....	33.14	18.94	16.57	14.73	13.26	12.75	12.05	11.63	11.03	
58.....	33.72	19.27	16.86	14.99	13.49	12.98	12.26	11.84	11.22	
59.....	34.30	19.60	17.15	15.25	13.72	13.20	12.47	12.04	11.41	
60.....	34.88	19.93	17.44	15.50	13.95	13.42	12.68	12.24	11.61	
61.....	35.47	20.27	17.73	15.76	14.19	13.65	12.90	12.45	11.80	
62.....	36.05	20.60	18.02	16.02	14.42	13.87	13.11	12.65	11.99	
63.....	36.63	20.93	18.31	16.28	14.65	14.09	13.32	12.86	12.19	
64.....	37.21	21.26	18.60	16.54	14.88	14.32	13.53	13.06	12.38	
65.....	37.79	21.59	18.90	16.80	15.12	14.54	13.74	13.27	12.57	
66.....	38.37	21.93	19.19	17.05	15.35	14.77	13.95	13.47	12.77	
67.....	38.95	22.26	19.48	17.31	15.58	14.99	14.16	13.67	12.96	
68.....	39.53	22.59	19.77	17.57	15.81	15.21	14.38	13.88	13.15	
69.....	40.12	22.92	20.06	17.83	16.05	15.44	14.59	14.08	13.35	
70.....	40.70	23.26	20.35	18.09	16.28	15.66	14.80	14.29	13.54	
71.....	41.28	23.59	20.64	18.35	16.51	15.88	15.01	14.49	13.73	
72.....	41.86	23.92	20.93	18.60	16.74	16.11	15.22	14.69	13.93	
73.....	42.44	24.25	21.22	18.86	16.98	16.33	15.43	14.90	14.12	
74.....	43.02	24.58	21.51	19.12	17.21	16.55	15.64	15.10	14.31	
75.....	43.60	24.92	21.80	19.38	17.44	16.78	15.86	15.31	14.51	
76.....	44.19	25.25	22.09	19.64	17.67	17.00	16.07	15.51	14.70	
77.....	44.77	25.58	22.38	19.90	17.91	17.23	16.28	15.71	14.89	
78.....	45.35	25.91	22.67	20.16	18.14	17.45	16.49	15.92	15.09	
79.....	45.93	26.25	22.97	20.41	18.37	17.67	16.70	16.12	15.28	
80.....	46.51	26.58	23.26	20.67	18.60	17.90	16.91	16.33	15.47	
81.....	47.09	26.91	23.55	20.93	18.84	18.12	17.12	16.53	15.67	
82.....	47.67	27.24	23.84	21.19	19.07	18.34	17.34	16.73	15.86	
83.....	48.26	27.57	24.13	21.45	19.30	18.57	17.55	16.94	16.05	
84.....	48.84	27.91	24.42	21.71	19.53	18.79	17.76	17.14	16.25	

Table 12.--Equipment valuation and depreciation, by region,
packaged milk transport unit, 1966

Region and equipment	New cost	Salvage value	Years to depreciate	Yearly depreciation
	-----Dollars-----			-----Dollars-----
East:				
Tractor.....	18,000	1,000	7	2,429
Trailer.....	11,500	1,000	8	1,312
Refrigeration.....	5,000	-----	6	833
Total.....	34,500			4,574
Midwest:				
Tractor.....	17,000	1,000	7	2,286
Trailer.....	11,000	1,000	8	1,250
Refrigeration.....	5,000	-----	6	833
Total.....	33,000			4,369
West:				
Tractor.....	23,000	1,000	7	3,143
Trailer.....	11,000	1,000	8	1,250
Refrigeration.....	5,000	-----	6	833
Total.....	39,000			5,226
United States:				
Tractor.....	19,300	1,000	7	2,619
Trailer.....	11,170	1,000	8	1,271
Refrigeration.....	5,000	-----	6	833
Total.....	35,470			4,723

Table 13.--Annual fixed costs by region, for packaged
milk transport unit, 1966

Cost item	East	Midwest	West	Average
	-----Dollars-----			
Depreciation:				
Equipment.....	4,574	4,369	5,226	4,723
Building and tools.....	220	250	225	232
Insurance.....	1,025	1,000	1,581	1,202
Interest.....	1,035	990	1,170	1,064
Federal highway-use tax.....	180	180	180	180
License and miscellaneous tax.....	525	800	643	656
Management and office salaries.....	973	973	973	973
Administrative costs.....	649	649	649	649
Total.....	9,181	9,211	10,647	9,679
Per hour <u>1</u> /.....	1.0481	1.0515	1.2154	1.1049

1/ Based on 8,760 hours of available operating time per year.

Table 14.---Hours required per trip to perform various functions,
packaged milk transport unit, 1966

Round- trip mileage	Function										Total truck time		Refriger-		ation time		ation cost	
	Check- out	Loading	Unloading	Maintenance	Driving time	Driver laidover 1 man	Idle time	1 driver	2 drivers	1/	2/							
10.....	1	1	1.5	0.10	0.25	0	16	19.85	---	2.75	1.43							
20.....	1	1	1.5	.10	.50	0	16	20.10	---	3.00	1.56							
40.....	1	1	1.5	.12	1.00	0	16	20.62	---	3.50	1.82							
50.....	1	1	1.5	.15	1.25	0	16	20.90	---	3.75	1.95							
70.....	1	1	1.5	.18	1.75	0	16	21.43	---	4.25	2.21							
80.....	1	1	1.5	.20	2.00	0	16	21.70	---	4.50	2.34							
100.....	1	1	1.5	.25	2.50	0	16	22.25	---	5.00	2.60							
150.....	1	1	1.5	.38	3.67	0	16	23.55	---	6.17	3.21							
200.....	1	1	1.5	.50	5.00	0	16	25.00	---	7.50	3.90							
250.....	1	1	1.5	.67	6.25	0	16	26.42	---	8.75	4.55							
300.....	1	1	1.5	.75	7.50	0	16	27.75	---	10.00	5.20							
350.....	1	1	1.5	.88	8.75	0	16	29.13	---	11.25	5.85							
400.....	1	1	1.5	1.00	10.00	0	16	30.50	---	12.50	6.50							
410.....	1	1	1.5	1.00	10.25	8	16	38.75	30.75	12.75	6.63							
800.....	1	1	1.5	1.50	20.00	8	16	49.00	41.00	22.50	11.70							
810.....	1	1	1.5	1.50	20.25	16	16	57.25	41.25	22.75	11.83							
1,200.....	1	1	1.5	2.50	30.00	16	16	68.00	52.00	32.50	16.90							
1,210.....	1	1	1.5	2.50	30.25	24	16	76.25	52.25	32.75	17.03							
1,600.....	1	1	1.5	3.00	40.00	24	16	86.50	62.50	42.50	22.10							
1,610.....	1	1	1.5	3.00	40.25	32	16	94.75	62.75	42.75	22.23							
2,000.....	1	1	1.5	4.00	50.00	32	16	105.50	73.50	52.50	27.30							
2,400.....	1	1	1.5	4.50	60.00	40	16	124.00	84.00	62.50	32.50							
2,800.....	1	1	1.5	5.00	70.00	48	16	142.50	94.50	72.50	37.70							
3,200.....	1	1	1.5	5.50	80.00	56	16	161.00	105.00	82.50	42.90							

1/ Includes loading, unloading, and driving time.

2/ Based on operating time cost of 52 cents per hour.

Estimated costs of transporting packaged milk are summarized for each region in table 15; total cost functions for each region are listed in table 16; and cost per hundredweight per mile, related to mileage, is shown in figure 3.

Average costs for transporting packaged milk differed from those for bulk milk. For distances of less than 100 miles one-way, the average cost to transport 100 pounds of milk was greater for the bulk truck than for the packaged unit. Beyond 100 miles, the reverse was true.

Table 15.--Estimated cost of transporting packaged milk over various distances, by region, 1966 ^{1/}

One-way mileage	East				Midwest			
	Per cwt.	Per mile	Per cwt. per mile	Per half gallon	Per cwt.	Per mile	Per cwt. per mile	Per half gallon
-----Cents-----								
5.....	6.992	489.400	1.3984	0.3021	7.011	490.800	1.4022	0.3030
10.....	7.743	271.000	.7743	.3346	7.763	271.700	.7763	.3354
20.....	9.251	161.900	.4626	.3998	9.271	162.250	.4636	.4006
25.....	10.012	140.160	.4005	.4326	10.032	140.440	.4013	.4335
35.....	11.523	115.229	.3292	.4979	11.544	115.429	.3298	.4988
40.....	12.280	107.450	.3070	.5306	12.301	107.625	.3075	.5315
50.....	13.797	96.580	.2759	.5962	13.819	96.740	.2764	.5972
75.....	17.557	81.933	.2341	.7586	17.579	82.040	.2344	.7596
100.....	21.384	74.840	.2138	.9240	21.408	74.930	.2141	.9251
125.....	25.190	70.536	.2015	1.0885	25.216	70.608	.2017	1.0896
150.....	28.970	67.593	.1931	1.2517	28.997	67.660	.1933	1.2530
175.....	32.764	65.531	.1872	1.4158	32.793	65.577	.1874	1.4168
200.....	36.556	63.975	.1828	1.5796	36.586	64.025	.1829	1.5809
205.....	38.959	66.517	.1900	1.6835	39.422	67.307	.1923	1.7035
400.....	69.975	61.228	.1749	3.0236	70.860	62.003	.1772	3.0619
405.....	70.766	61.156	.1747	3.0578	71.663	61.931	.1769	3.0965
600.....	101.932	59.460	.1699	4.4044	103.251	60.230	.1721	4.4615
605.....	102.723	59.426	.1698	4.4386	104.053	60.197	.1720	4.4962
800.....	133.739	58.511	.1672	5.7789	135.491	59.278	.1694	5.8546
805.....	134.530	58.492	.1671	5.8131	136.293	59.258	.1693	5.8893
1000.....	165.696	57.994	.1657	7.1598	167.882	58.756	.1679	7.2538
1200.....	197.503	57.605	.1646	8.5341	200.122	58.369	.1668	8.6473
1400.....	229.310	57.328	.1638	9.9085	232.362	58.091	.1660	10.0404
1600.....	261.117	57.119	.1632	11.2828	264.602	57.882	.1654	11.4335
-----Cents-----								
One-way mileage	West				Average			
	Per cwt.	Per mile	Per cwt. per mile	Per half gallon	Per cwt.	Per mile	Per cwt. per mile	Per half gallon
5.....	7.932	555.200	1.5864	.3427	7.311	551.800	1.4622	.3159
10.....	8.687	304.000	.8687	.3753	8.064	282.200	.8064	.3484
20.....	10.203	178.550	.5102	.4409	9.575	167.550	.4788	.4137
25.....	10.968	153.560	.4387	.4740	10.336	144.720	.4134	.4467
35.....	12.487	124.886	.3568	.5396	11.851	118.514	.3386	.5121
40.....	13.249	115.925	.3312	.5725	12.609	110.325	.3152	.5448
50.....	14.775	103.420	.2955	.6384	14.130	98.900	.2826	.6105
75.....	18.554	86.587	.2474	.8017	17.896	83.520	.2386	.7733
100.....	22.407	78.420	.2241	.9681	21.732	76.060	.2173	.9390
125.....	26.239	73.472	.2099	1.1338	25.548	71.536	.2044	1.1040
150.....	30.039	70.093	.2003	1.2980	29.335	68.447	.1956	1.2675
175.....	33.857	67.714	.1935	1.4630	33.137	66.274	.1894	1.4319
200.....	37.671	65.925	.1884	1.6278	36.937	64.640	.1847	1.5960
205.....	40.042	68.366	.1953	1.7302	39.470	67.385	.1925	1.7054
400.....	71.180	62.282	.1780	3.0757	70.663	61.830	.1767	3.0533
405.....	71.974	62.200	.1777	3.1100	71.459	61.756	.1764	3.0878
600.....	103.286	60.250	.1721	4.4630	102.810	59.972	.1714	4.4423
605.....	104.080	60.212	.1720	4.4973	103.606	59.937	.1712	4.4768
800.....	135.218	59.158	.1690	5.8427	134.799	58.975	.1685	5.8247
805.....	136.011	59.135	.1690	5.8770	135.595	58.954	.1684	5.8590
1000.....	167.323	58.563	.1673	7.2300	166.946	58.431	.1669	7.2137
1200.....	199.255	58.116	.1660	8.6098	198.935	58.022	.1658	8.5959
1400.....	231.187	57.797	.1651	9.9896	230.924	57.731	.1649	9.9781
1600.....	263.119	57.558	.1644	11.3694	262.913	57.512	.1643	11.3604

^{1/} Assuming 35,000 lbs., or 8,100 half-gallon cartons of milk.

Table 16.--Packaged milk transportation cost functions, 1966

One-way : mileage : interval :	Applicable equations 1/			
	East	Midwest	West	Average 2/
0 - 50....	$Y = 6.236 + .15122 X$	$Y = 6.254 + .15129 X$	$Y = 7.172 + .15207 X$	$Y = 6.554 + .15153 X$
51 - 200..	$Y = 6.210 + .15173 X$	$Y = 6.230 + .15178 X$	$Y = 7.143 + .15264 X$	$Y = 6.527 + .15205 X$
201 - 400.	$Y = 6.352 + .15906 X$	$Y = 6.372 + .16122 X$	$Y = 7.307 + .15968 X$	$Y = 6.677 + .15996 X$
401 - 600.	$Y = 6.037 + .15983 X$	$Y = 6.057 + .16199 X$	$Y = 6.941 + .16057 X$	$Y = 6.345 + .16077 X$
601 - 800.	$Y = 6.494 + .15906 X$	$Y = 6.515 + .16122 X$	$Y = 7.472 + .15968 X$	$Y = 6.828 + .15996 X$
801 plus..	$Y = 6.349 + .15923 X$	$Y = 6.682 + .16120 X$	$Y = 7.663 + .15966 X$	$Y = 6.689 + .16014 X$

1/ Y = cents per cwt. X = one-way mileage.

2/ The aggregate function (disregarding 1- and 2-driver operations) for all distances up to 1,600 miles is $Y = 6.513 + .16025 X$.

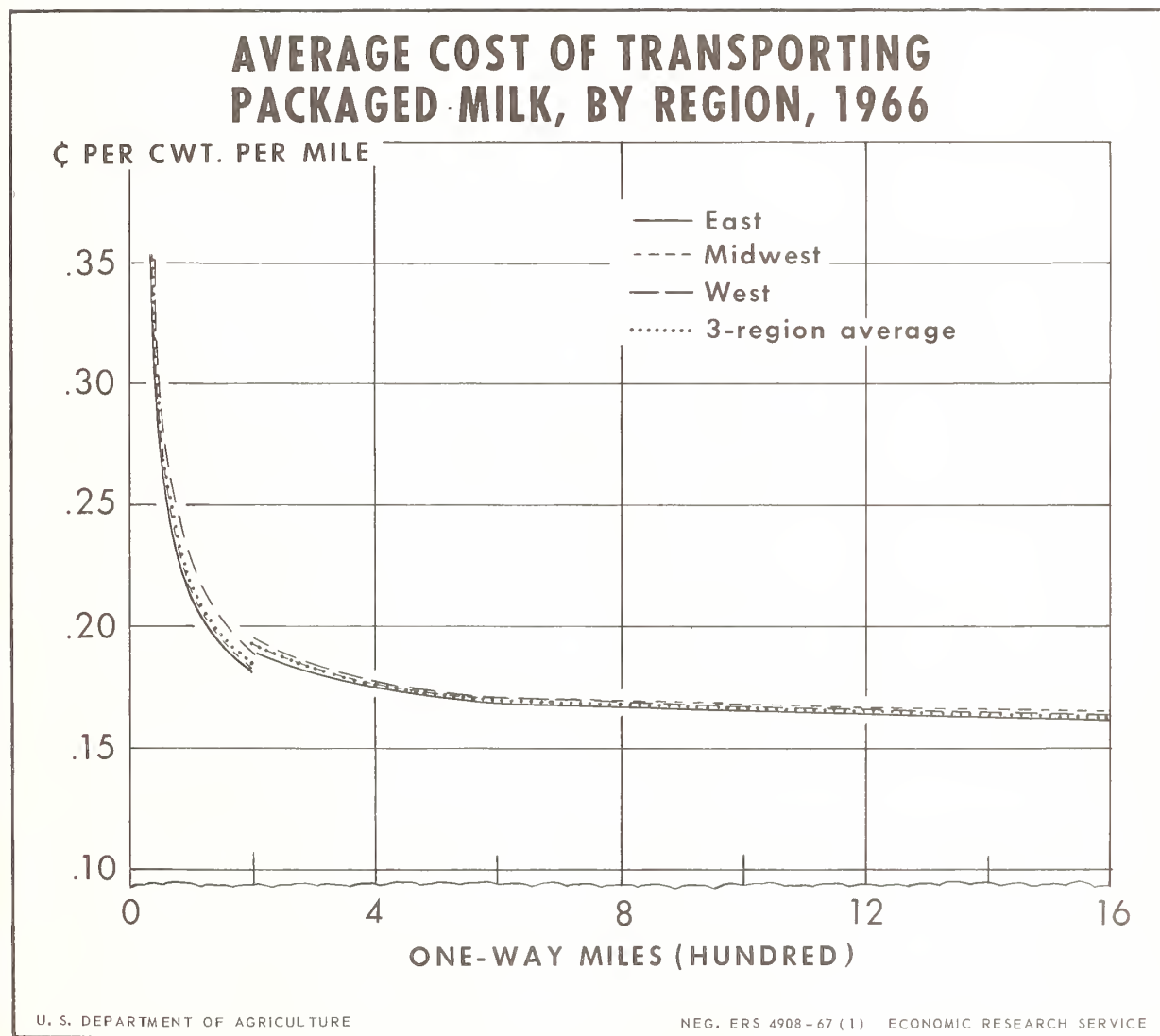


Figure 3

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APPENDIX

Truck Usage

This study illustrated truck usage by presenting two situations. In the one situation, no seasonality was present and fixed costs were determined on the basis of 8,760 hours of truck time per year. In the other situation, milk shipments were assumed to be seasonal and fixed costs were derived on the basis of 5,919 hours of truck time per year. The methodology used for these examples can be applied to a variety of other situations as well.

Milk haulers prefer long hauls, although few of these hauls exist. Generally, as the length of trip increases, the number of trips available decreases. Therefore, hauling costs were analyzed by asserting that a truck would not be associated

with only one length of haul during its life, but rather with several lengths of trips. The depreciation of 7 years for the tractor takes into account several lengths of hauls. With a mixture of trip lengths during the year, the total mileage over the life of the truck approximates the actual mileage associated with the usual truck life expressed by haulers.

The following example, using four lengths of trips, illustrates the relationship between length of trips, frequency of trips, and total mileage during the life of the truck. In the table below, the miles traveled per year for each trip were computed by first dividing 5,919 hours (truck time available during one year, based on seasonality of shipments) by the total truck time (from table 1) for two drivers for that particular length of trip (column 2 in the tabulation below). This quotient (column 3) was then multiplied by the number of miles per trip (column 1) to obtain the total miles per year (column 4) if the truck were used only for that length of trip. However, short trips occur more frequently than long trips. The frequency of the trip (column 5) was then applied to the product in column 4 to derive the miles per year for a particular trip (column 6).

		All trips same length		Trips of varying length	
(1)	(2)	(3)	(4)	(5)	(6)
Round-trip : mileage :	Truck time, 2 : drivers (hours) :	Trips per year : (number) :	Total miles : per year :	Frequency of : trip per year : (percent) :	Miles per : year :
100	23.25	255	25,500	50	12,750
800	42.00	141	112,800	30	33,840
2,000	74.50	79	158,000	15	23,700
3,200	106.00	56	179,200	5	8,960
Total miles per year for 1 truck				100	79,250
Total miles over life of truck (7 years)					554,750

If a truck were to be used exclusively for a given length of trip, then some adjustments in the data would be necessary. Adjustments in depreciation would be required so that mileage over the life of the truck used for only one length of trip would correspond with the total mileage required from the truck. If the truck were used for long hauls, the total miles per year might be so great that the truck would be depreciated out in 3 years instead of 7 years. This could occur because certain time requirements are the same for all trips; thus, total mileage per year would be greater if all trips were long rather than a mixture of trip lengths.

The truck speed used in the analysis represents an average speed covering varying types of roads. In areas where only high-speed freeways and turnpikes are used for most trips, average speeds would be greater than 40 m.p.h. On the other hand, in mountainous areas or regions where freeways are not present, truck speeds would probably not be greater than 30 to 35 m.p.h. Therefore, in an area where average speed differs greatly from 40 m.p.h., adjustments to hours per trip in table 1 would be necessary.

If truck speed differed from 40 m.p.h., the total hours per trip--and thus the fixed cost per trip--would vary. Assuming a speed of less than 40 m.p.h., the total hours per trip and fixed cost per trip would increase. For speeds greater than

40 m.p.h., the fixed costs per trip would decrease because the time per trip would be reduced.

Any changes in the average speed necessarily alter the number of hours per trip and, therefore, the number of miles traveled per year. This would have to be taken into account by adjusting the number of years the truck is depreciated.

Any number of situations can be analyzed by making the proper adjustments in the time requirements per trip and the depreciation.

Symbolic Derivation of Costs 5/

The total cost per mile to operate the bulk milk tractor and trailer unit is composed of fixed, variable, and transfer costs, that is,

$$TC_m = F_m + V_m + Tr_m$$

where TC_m = total cost per mile,

F_m = fixed cost per mile,

V_m = variable cost per mile, and

Tr_m = transfer cost per mile.

Fixed Cost

$$F_t = \left(\frac{D + I + R + T + E + A}{H_y} \right) H_t$$

$$F_m = \frac{F_t}{M_t}$$

where F_t = fixed cost per trip,

D = depreciation per year,

I = insurance per year,

R = interest per year,

T = taxes per year,

E = management expenses per year,

A = administrative expenses per year,

H_y = hours truck in use per year,

H_t = hours truck in use per trip,

F_m = fixed cost per mile, and

M_t = miles per trip.

5/ An alternative way to determine total cost per mile is to sum the total variable cost, the total transfer cost, and the total fixed cost per trip and divide by the mileage per trip. This alternative was used in this report.

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Variable Cost

$$V_m = P + L + W + S + O$$

where V_m = variable cost per mile,

P = fuel cost per mile,

L = labor cost per mile,

W = tire cost per mile,

S = maintenance cost per mile, and

O = miscellaneous cost per mile.

Transfer Cost

$$Tr_m = \frac{CN}{Mt}$$

where Tr_m = transfer cost per mile,

C = cost of transferring 100 pounds of milk,

N = hundredweight of milk transferred, and

Mt = miles per trip.

